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Global usage of selected persistent organochlorines

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Abstract

Information on historical and future trends in use and emissions of persistent organochlorines on a global scale is essential for interpreting present and predicting future environmental concentrations of these compounds in remote regions. In this study, which is now a recognized project under the Global Emissions Inventory Activity of the International Geosphere Biosphere Program, information on registration status, trends in regional use/emissions, and mode and time of applications of 10 pesticides is being compiled. Results pertaining to four pesticides are presented here. The cumulative global usage accounted for (in metric tonnes) is 450 000 for toxaphene, 1 500 000 for DDT, 550 000 for technical HCH, and 720 000 for lindane. The interpolated usage of toxaphene and DDT was 1 330 000 and 2 600 000 tonnes from 1950 to 1993 and 670 000 and 990 000 tonnes from 1970 to 1993. The compounds are still legally used in several countries, and illegal use in other countries has been suggested. International cooperation, changes in legislations and regulations, and improved record keeping by governments and other bodies are required to restrict usage, as well as to improve the estimates.

Keywords: Organochlorine pesticides; DDT; HCH; Lindane; Toxaphene

1. Introduction

Persistent organochlorine pesticides such as PCBs, DDT, and hexachlorocyclohexane (HCH) are distributed globally throughout the environment. Although there are no major sources in the polar regions, these pesticides have been measured in air, sea water, ice, and mammals in the Antarctic (Tanabe et al., 1983a,b; Iwata et al., 1993). DDT, hexachlorocyclohexane, toxaphene, and other organochlorines are found in air, snow, water, suspended sediments, birds, fish, marine flora, mammals, and humans in the Arctic (as reviewed by Barrie et al., 1992; Muir et al., 1992; Thomas et al., 1992). Toxaphene is now the most abundant pesticide in arctic aquatic life (as reviewed by Muir et al., 1992) and concentration of HCH is higher in arctic waters than in more southern waters (Muir et al., 1992; Iwata et al., 1993). The impact of these contaminants on ecosystems and humans is of great concern, as summarized in recent reviews (Colborn and Clement, 1992; Swain et al., 1992; Colborn et al., 1993) and reflected, for example, in the mandate of the Task Force of Persistent Organic Pollutants of the United Nations Economic Commission for Europe, UN ECE/TF POP (1992).

The contaminants enter the arctic environment mainly through atmospheric transport, rivers, and

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ocean currents. The northward migration of these persistent contaminants through the ecosystem, the hemispherical (and even global) aspect of the transport, and the importance of the various routes of entry have been the subject of several papers (Barrie et al., 1992; Iwata et al., 1993). The present inputs are the legacy of past pesticide use along with fresh applications.

Atmospheric and ecosystems models are now emerging, which will aid in determining these inputs and in differentiating between contributions from past use and from current sources. The models will also have value in predicting how these inputs, as well as concentrations in the various environmental compartments, may change in the future and what, if any, the recovery rate of the system would be if the pesticides were further restricted or banned globally (Pudykiewitz, 1989; Strand, 1993; Wania and Mackay, 1994). However, these models require information on usage or emissions of the pesticides, which is not readily available.

This paper describes a research study conducted to compile information on global usage of HCH, lindane, DDT, and toxaphene. Based on this information, emissions from selected regions will be estimated with an air/vegetated soil model.

2. Description

The purpose of this effort was to compile information and create a computerized database of historical, present, and predicted global usage and the production or sale of the highly toxic, persistent pesticides: aldrin, dieldrin, chlordane, DDT, endosulphane, endrin, heptachlor, HCH, lindane, and toxaphene. Only the results for DDT, toxaphene, HCH, and lindane are reported here. As the pesticides are banned or severely restricted in many countries, information was sought on registration status, in addition to amount of production, use, and emission; region of use or emission; mode and time of application; physical and chemical properties of the active ingredients, as well as of the technical mixture; and representative concentrations in soils. This information will be used to estimate emissions in selected

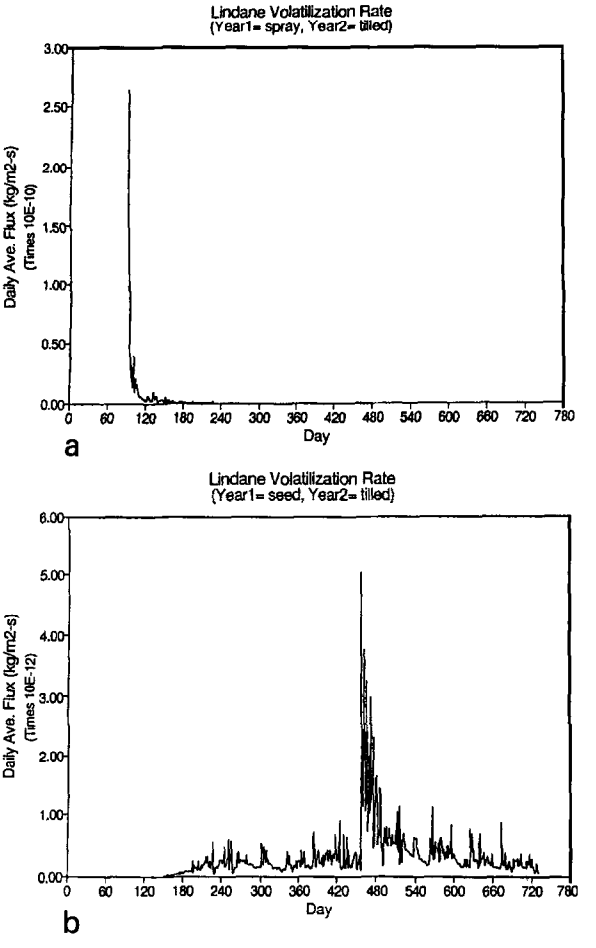

Fig. 1. (a) Temporal pattern of lindane emission rate following spray application on day 91; (b) Temporal pattern of lindane emission rate following in-furrow application on day 91 in year 1 and subsequent tilling on day 456 in year 2.

regions with an air/vegetated soil exchange model (Scholtz and Voldner, 1993).

The method of application of a pesticide has a strong influence on the rate of its volatilization. This is illustrated in Fig. 1a,b, which shows the temporal patterns of emissions of lindane when applied as surface spray and as treated seeds at a depth of 6–10 cm. The meteorological situation reflects conditions in southern Canada. With surface treatment, volatilization is high after application and decreases rapidly. The bulk of the pesticide has volatilized within a few days, with little remaining after 90 days. When applied as seed treatment, the rate of volatilization is low during the first year, due to the slow migration of the

pesticide to the surface. After tilling to a depth of 10 cm the following year, the rate of volatilization peaks as material is brought to the surface (Scholtz et al., 1993).

As there are no central registers for these toxic chemicals, the information was obtained through literature surveys, contacts and contracts with international agencies, and discussions with researchers. Sources of data include proprietary surveys, such as the World Agrochemical Data Bank by Battelle Europe (Battelle Europe, undated); special regional studies by Battelle (Biermann, personal communication); a highly spatially resolved but temporally limited database for the USA (Gianessi and Puffer, 1992); contracted studies arranged for Environment Canada by the International Register for Potentially Toxic Chemicals of the United Nations Environmental Program (IRPTC/UNEP, 1990); the Food and Agriculture Organization (FAO) Year Book of the United Nations, reports by the World Health Organization (Smith and Lossev, 1981); statistics compiled by the Government of India (Government of India, 1990; Pesticide Information, 1990); special studies for Central and Latin America, carried out for the Canadian Wildlife Service and the United Nations Industrial Development Organization (Maltby, 1980; Burton and Philogene, 1985; Voldner and Ellenton, 1988), and a report to the German Umweltbundesamt (Axenfeld et al., 1992). Through IRPTC/UNEP, information from the former Soviet Union, former German Democratic Republic, and the Peoples Republic of China was compiled by experts in these regions (Sun et al., 1992; IRPTC/UNEP, 1992; Beitz, 1993; Kundiev and Kagan, 1993a,b). Information on registration status was obtained from the United Nations (IRPTC/UNEP, 1990; UN, 1991),

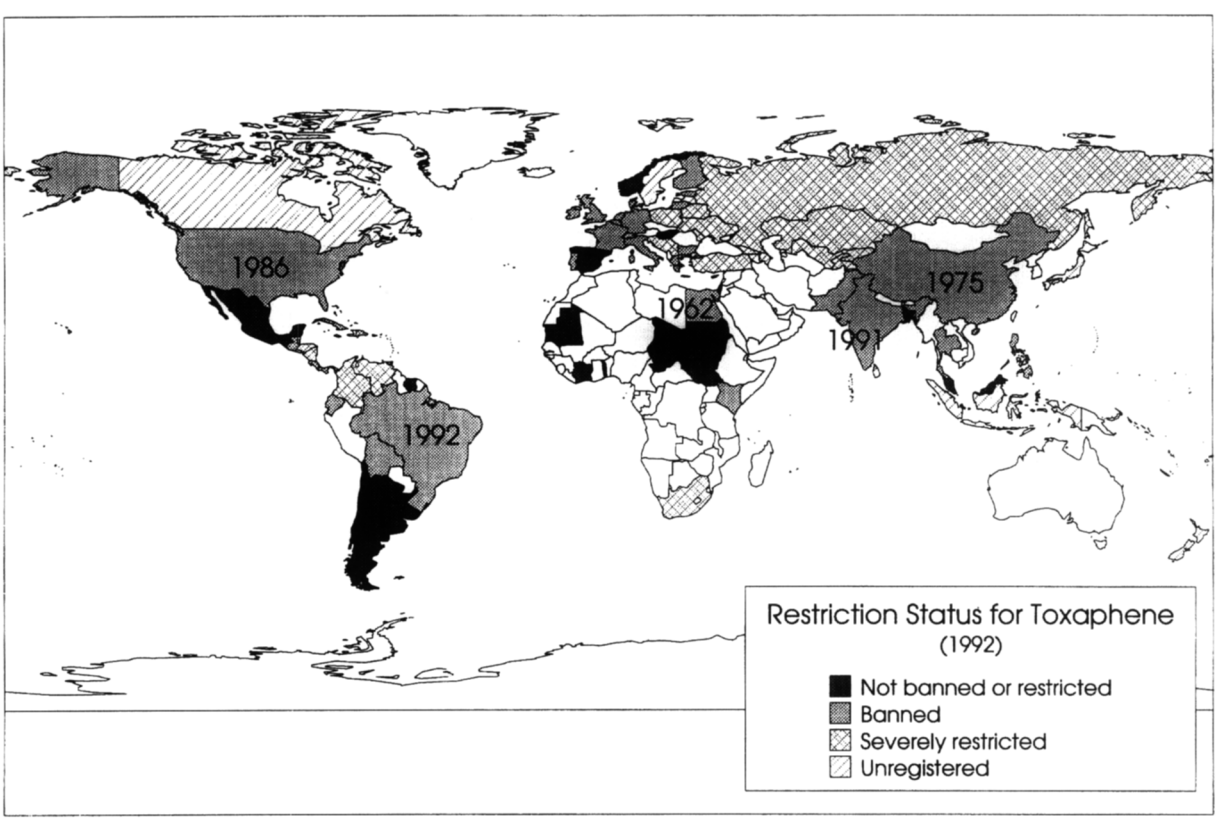

Fig. 2. Registration status of toxaphene surveyed in 1992.

the Pesticides Action Network (PAN, 1992), the UN ECE/TF POP (Fraunhofer Institute, 1993), and records from individual countries.

The data vary in quality and show large spatial and temporal gaps. Several countries do not keep records or have no reporting mechanism, whereas in others, information is proprietary. Reporting to FAO is voluntary. Canada provides a good example of proprietary information. Although Agriculture Canada has information on company and product sales statistics, as well as sales summaries broken down by province, product market type, use pattern and active ingredient, only composite information can be divulged. In 1988, over 2300 tonnes of active ingredients of insecticides were sold. Lindane was one of the 10 active ingredients, which accounted for approximately 65% of the sale (Agriculture Canada, 1992). The lack of disclosure is to ensure that the competitive position of a producer is not jeopardized. The situation in the USA is discussed by Bason and Colborn (1992). The World Agrochemical Data Bank, which is 'a key input to research and development and overall market planning' (Battelle Europe, undated), and other proprietary databases (Landell Mills, undated; Doane, undated), are costly to access and may require subscription. As the organochlorines have an established market, little information was retrieved from the Battelle database. The IRPTC/UNEP, with its excellent network of contacts, was able, through subcontracts, to compile information in the above noted regions. The difficulty of obtaining information is emphasized in these studies. To expand the investigation to other countries requires further funding.

The compiled data are difficult to interpret, as it is not always clear whether the active ingredient or a mixture is reported. When conflicting data were found for a period and region, the data

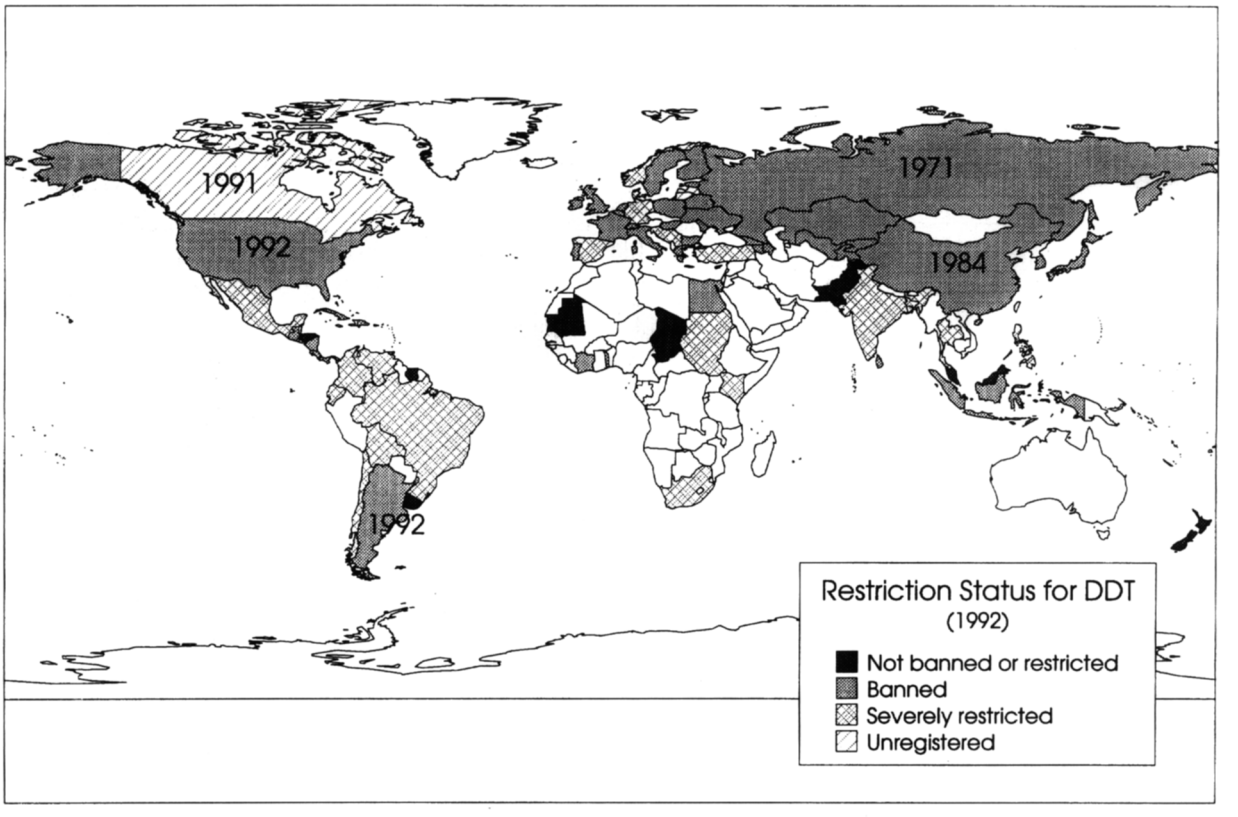

Fig. 3. Registration status of DDT surveyed in 1992.

deemed to be of the best quality were used. This subjective judgment was based on the method by which the data were obtained, comparison with other regions, and registration permits. No spatial interpolation was attempted; temporal interpolation was based on auxiliary information, such as production, export/import, and registration. When such information was not available, linear interpolation was resorted to. Obviously, this introduces a great deal of uncertainty into the reported amounts.

3. Results

Figs. 2–5 show the registration status of the pesticides. The figures indicate where the use of the pesticides is banned, where it is not registered, and where it is severely restricted. Also shown are regions for which no information was found. The year a pesticide was banned or deregistered is also noted for the larger countries. As shown in Fig. 2, toxaphene was banned in Egypt in 1962, in China in 1975, in the United States in 1986, in the German Democratic Republic in 1990, etc. These figures can be misleading. Although a pesticide was banned, it may still have been permitted for special applications; use of old stock may have been permissible or illegal use may have occurred after the ban (Larsson and Okla, 1989; PAN, 1992; Kundiev and Kagan, 1993a).

Figs. 6–9 provide the spatial distribution of the total amount of each pesticide, which was accounted for in the search. The amounts, in metric tonnes, were 450 000 for toxaphene, 1 500 000 for DDT, 550 000 for HCH, and 720 000 for lindane. Accumulated interpolated total use between 1970 and the present was 670 000 tonnes for toxaphene and 990 000 tonnes for DDT. Amounts between 1950 and the present were 1 330 000 tonnes for

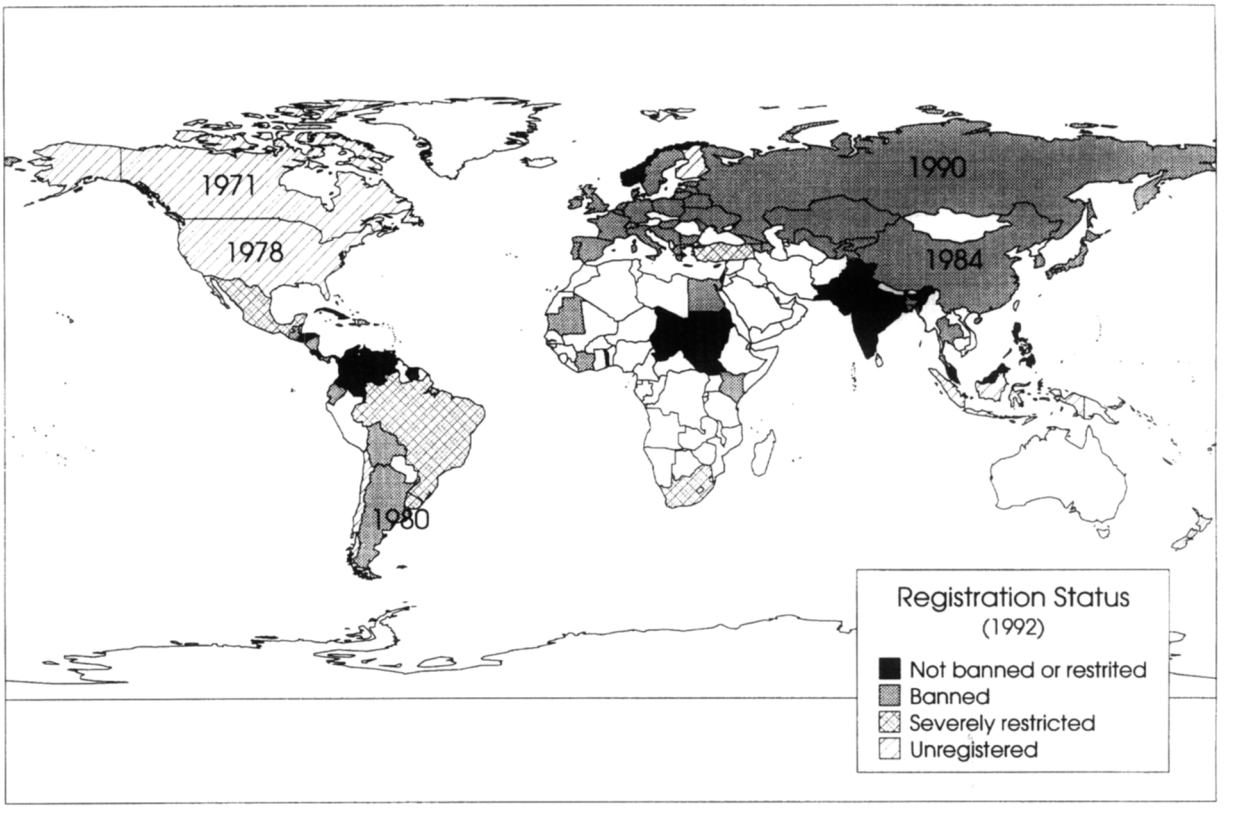

Fig. 4. Registration status of HCH surveyed in 1992.

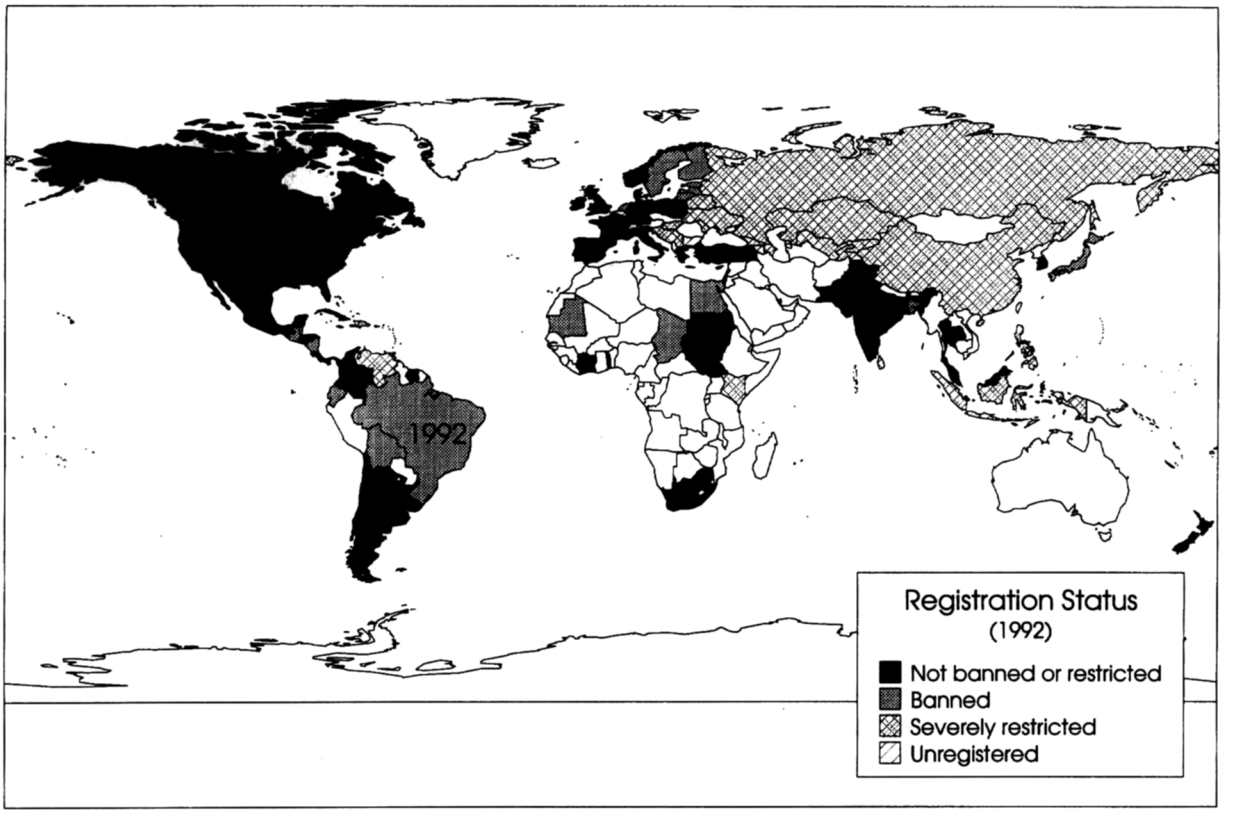

Fig. 5. Registration status of lindane surveyed in 1992.

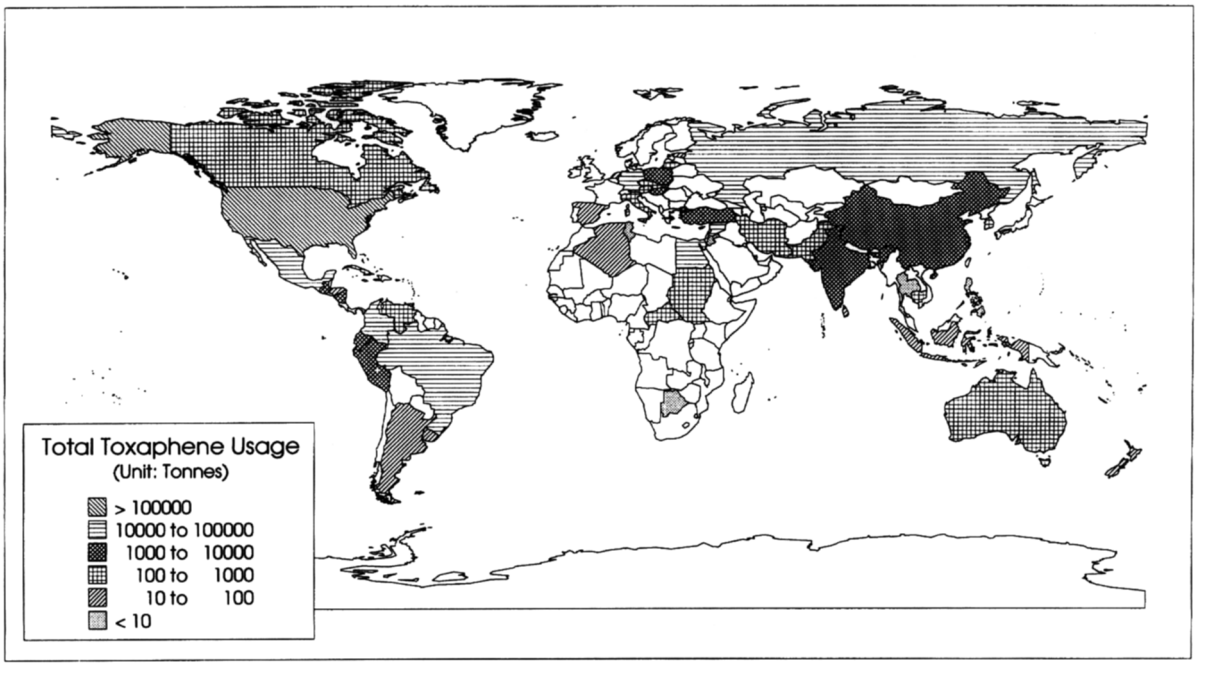

Fig. 6. Global toxaphene usage distribution accounted for in the search. The total usage was estimated at 450 000 metric tonnes.

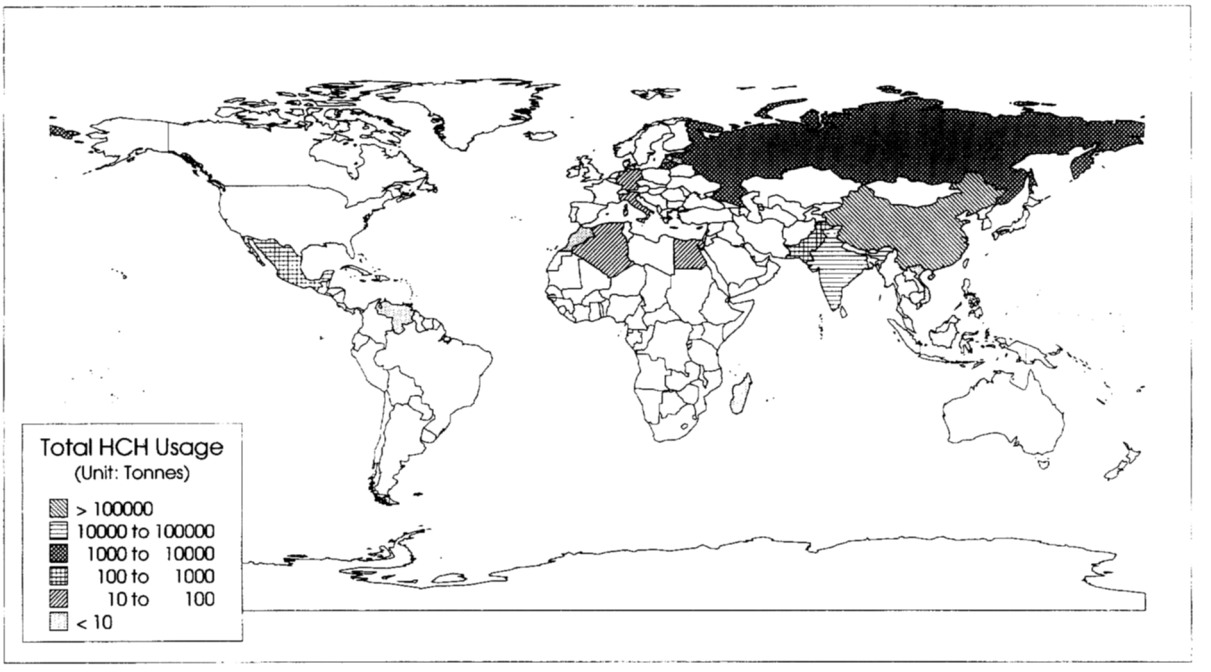

Fig. 7. Global DDT usage distribution accounted for in the search. The total usage was estimated at 1 500 000 metric tonnes.

toxaphene and 2 600 000 tonnes for DDT. The amount used in a country is indicated in the figures by shading and is shown for the whole country rather than attributed to a specific region. This can be very deceiving. For example, the usage of toxaphene in the United States was

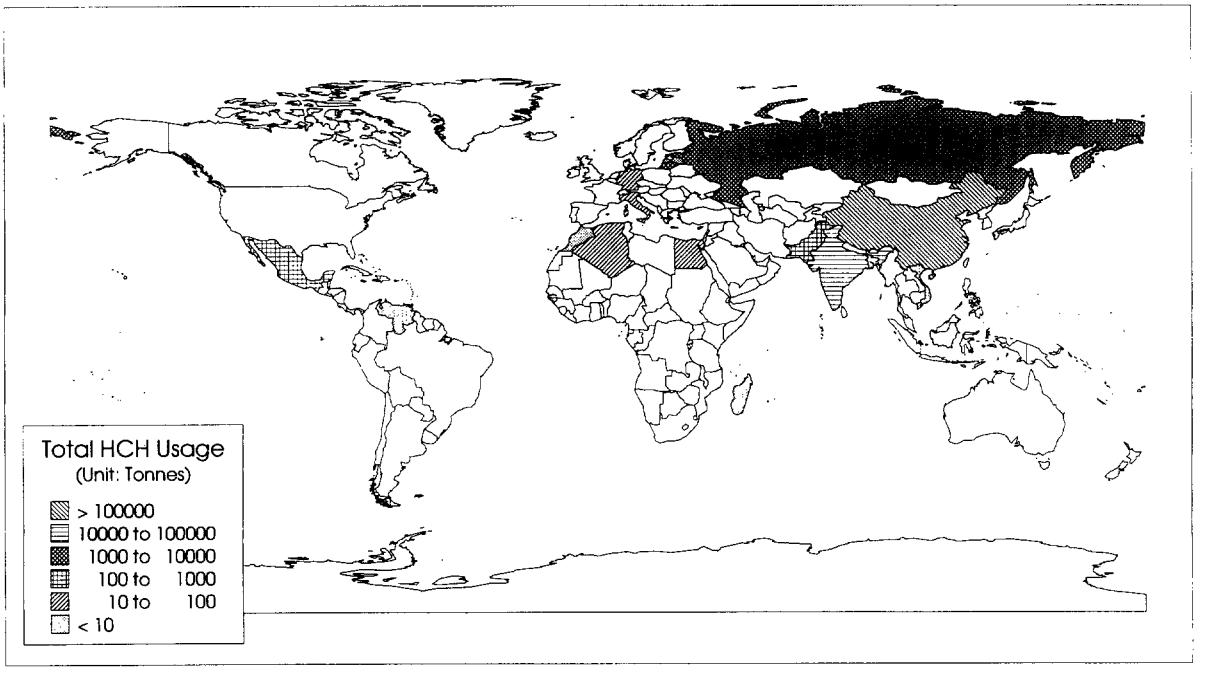

Fig. 8. Global HCH usage distribution accounted for in the search. The total usage was estimated at 550 000 metric tonnes.

primarily concentrated in the southern cotton belt, with no usage in Alaska (Voldner and Schroeder, 1989). The major pesticide use areas in the former Soviet Union include the Russian Federation and the Republics of Middle Asia (Kundiev and Kagan, 1993b). The largest amount of toxaphene appears to have been used in the United States, former Soviet Union, and Central America. This may in part be true, but it could be an artifact, since more detailed information was retrieved for these regions.

The above estimates do not include amounts of pesticides that have been placed in storage or disposed of as waste. Export of pesticide wastes from industrialized nations to developing countries is documented (Greenpeace Germany, 1992; Jain, 1992).

A change-over from technical HCH to lindane has occurred at different times in the various countries. The type of application also varies. Interestingly, HCH was used as a fog inducer by the military in the former German Democratic Republic (Beitz, 1993). In China, lindane was used to prevent infestation of locusts (Sun et al., 1992). Such information is valuable when interpreting environmental measurements such as isomer ratios and concentrations in air.

4. Conclusions

Data on the present and historical use of persistent organochlorines such as toxaphene are difficult to obtain and uncertain. The reported information should therefore be viewed with caution. It appears that many countries do not keep records on pesticides, whereas in other countries, such information is confidential. A limited number of countries report to FAO. Commercial databases such as those assembled by Battelle Europe are proprietary and costly to access. Although IRPTC/UNEP does not routinely compile information, information for the Peoples Republic of China, the former Soviet Union, and the German Democratic Republic has been obtained through its contact. To extend this service to other regions requires further funding.

To improve this database and the record of pesticide use in general, international cooperation is required. As a step in this direction, a project on organochlorines has been established

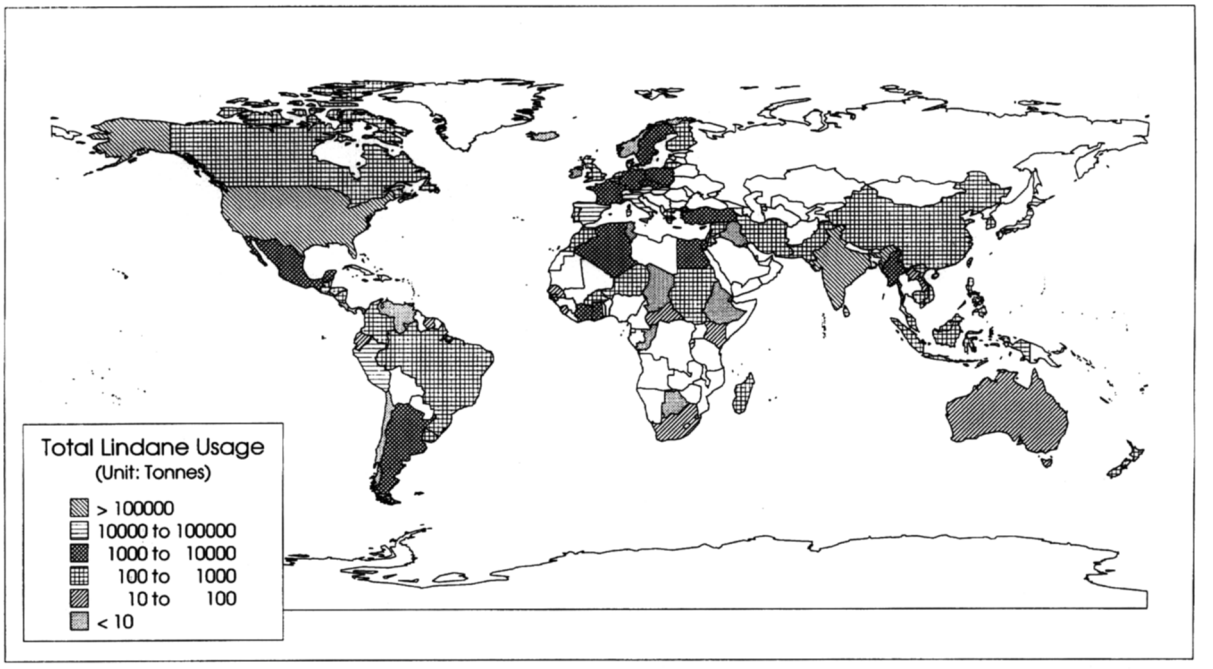

Fig. 9. Global lindane usage distribution accounted for in the search. The total usage was estimated at 720 000 metric tonnes.

under the Global Emissions Inventory Activity of the International Geosphere Biosphere Program. Anyone interested in participating in this project should contact the principal author.

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